Recent activities in the DES Supernova group

Sein Eun-Joo Ahn
Fermilab

Aim of DES is to study the nature of dark energy

DES has four probes to study dark energy:

1. clusters
2. large scale structures
3. weak lensing

} 5000 deg^2 survey

4. supernovae — 30 deg^2 repeated survey

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- observe sufficient SN to obtain redshift-brightness relation to measure equation of state of DE
- expect to observe ≈ 4000 SN Ia, up to z ≈ 1.2
- detection have happened even during Science Verification stage

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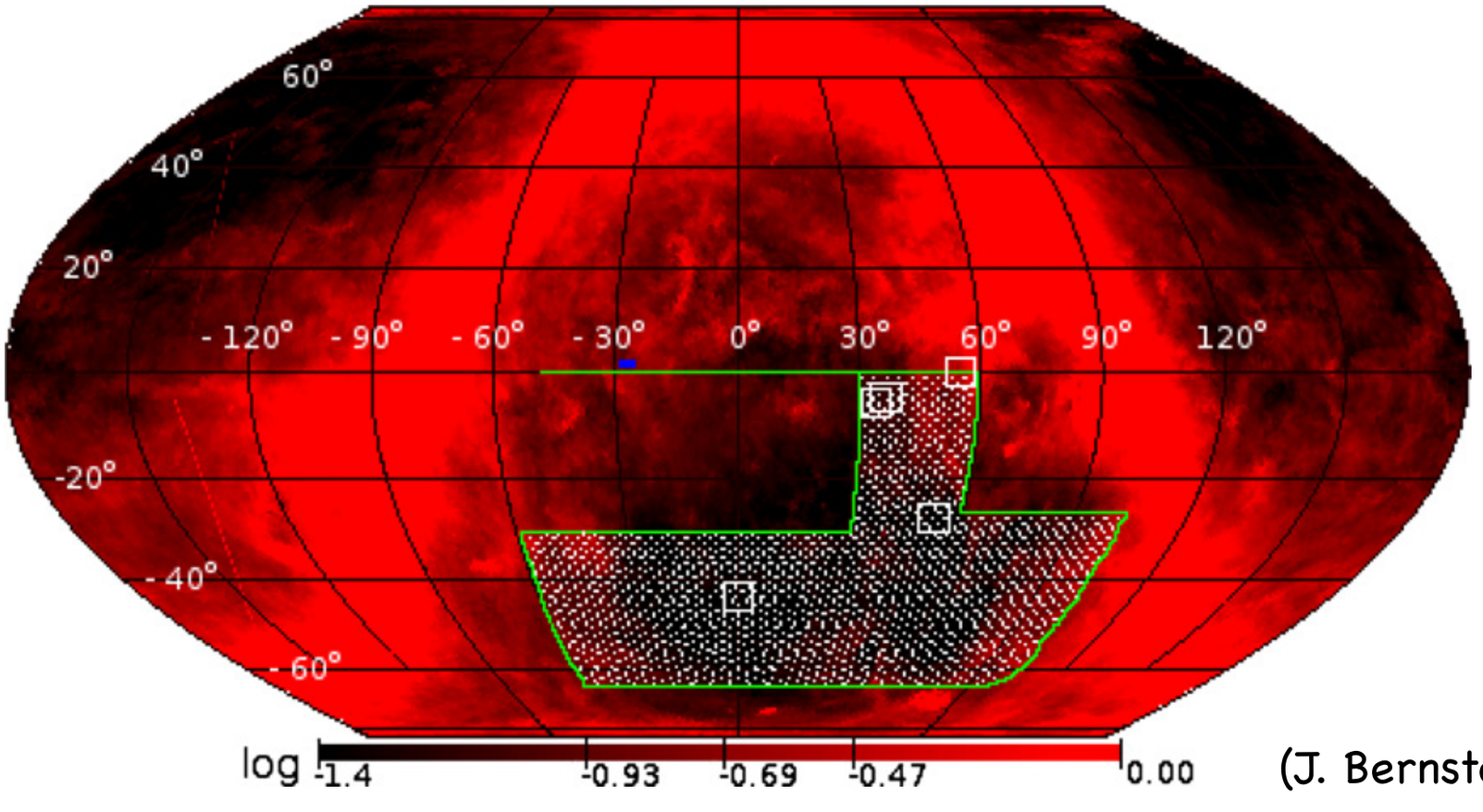

(J. Bernstein et al. ApJ 2012)

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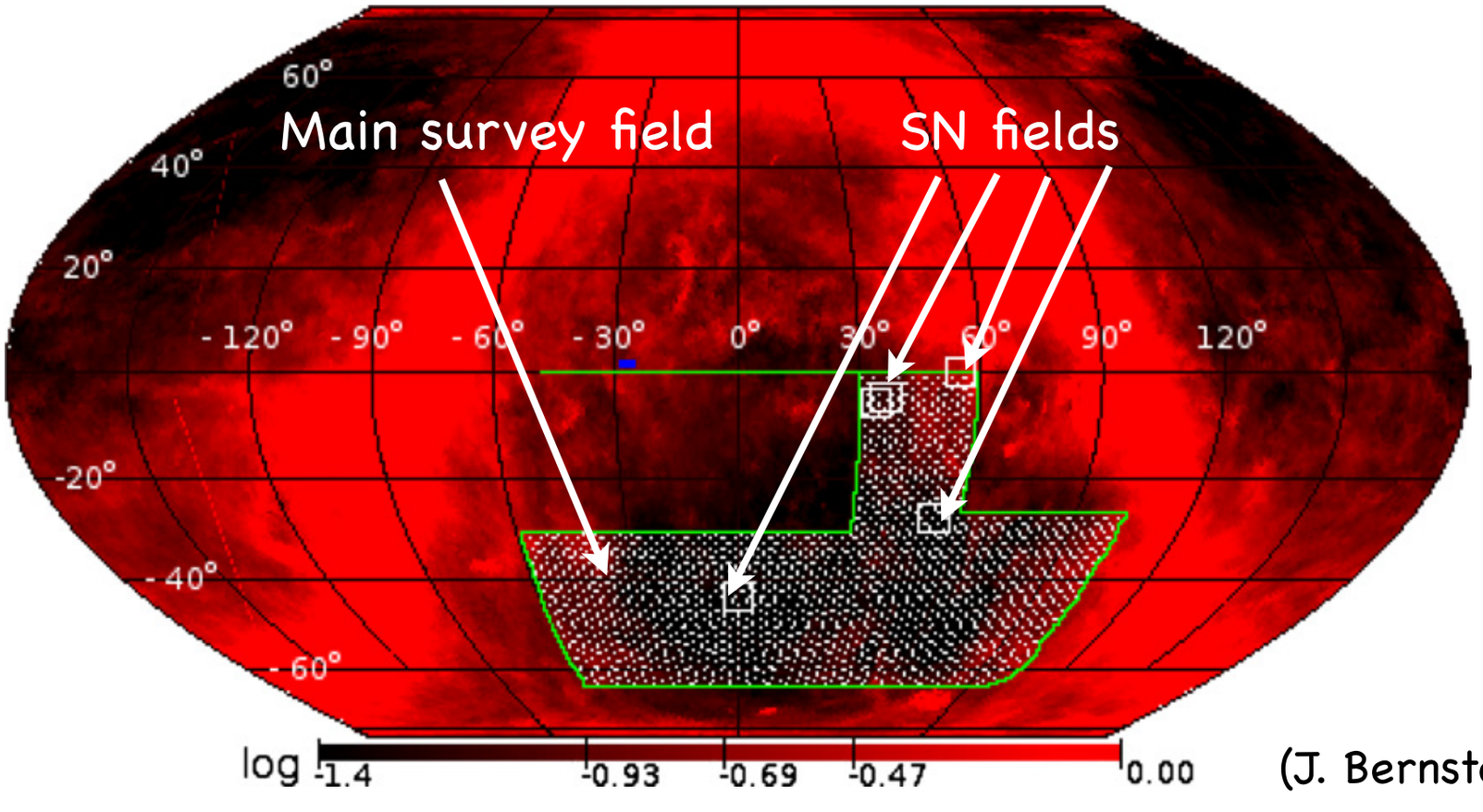

10 SN fields:

- 8 shallow
  i band: 200 sec exposure
  magnitude up to 25.9/year
- 2 deep
  i band: 1800 sec exposure
  magnitude up to 27.0/year

(J. Bernstein et al. ApJ 2012)

❖ SN working group has been very busy during Science Verification

★ Fermilab SN group is actively involved

- Eun-Joo Ahn, Dave Finley, Josh Frieman, John Marriner, Wyatt Merritt, William Wester and others

- Develop, test, run difference imaging software
- SN candidates selected -> scanned for real SN

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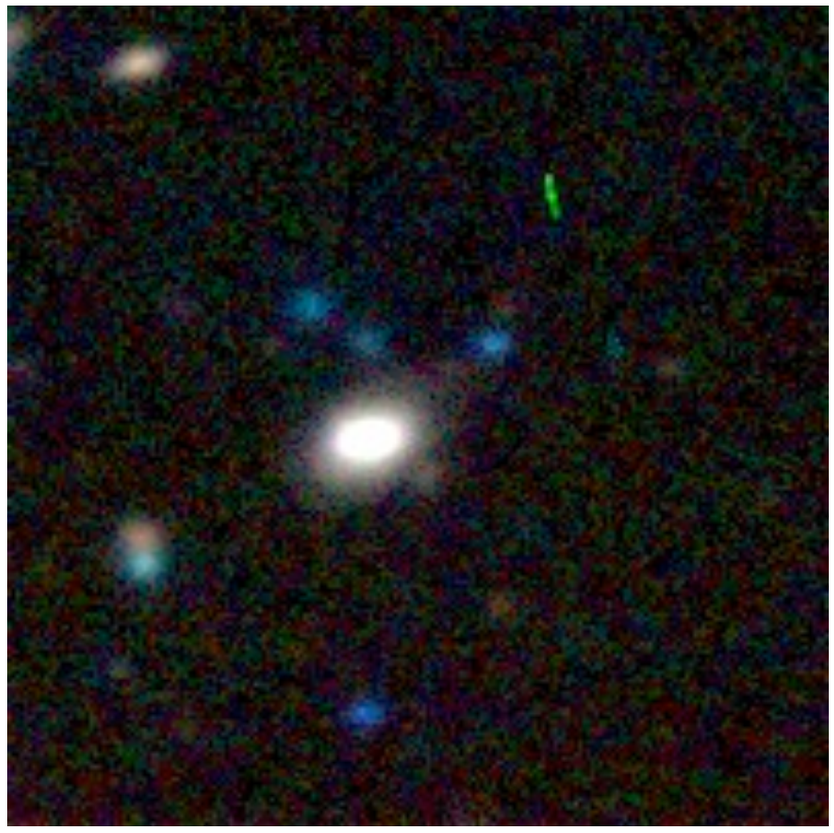
- make repeated observations of a given area in the sky, compare the images and look for differences.

Observed:
1) Nov 7th 2012



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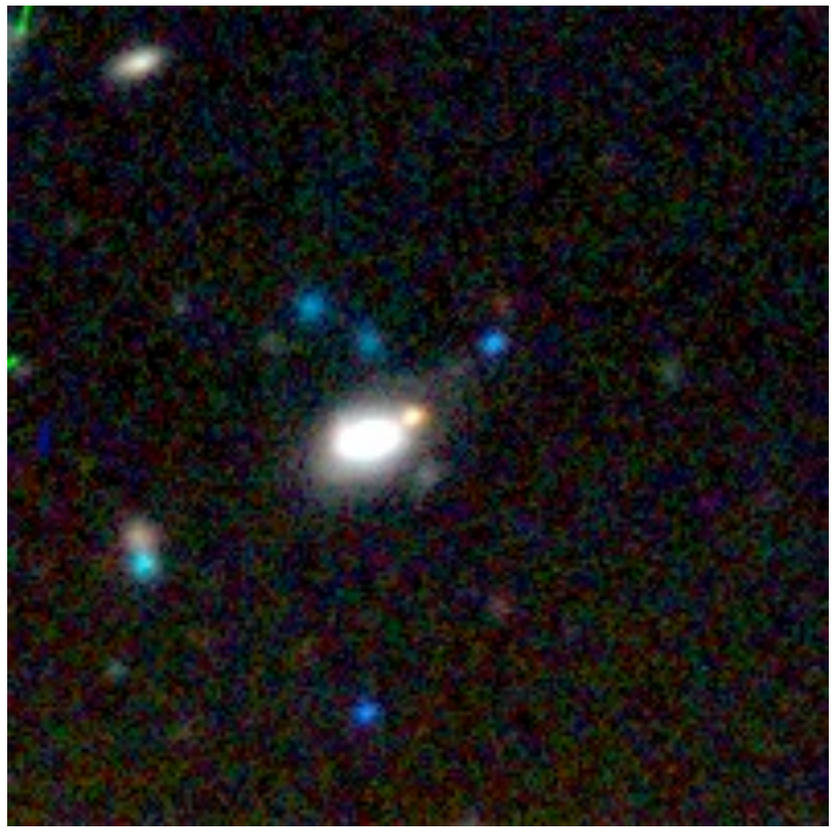

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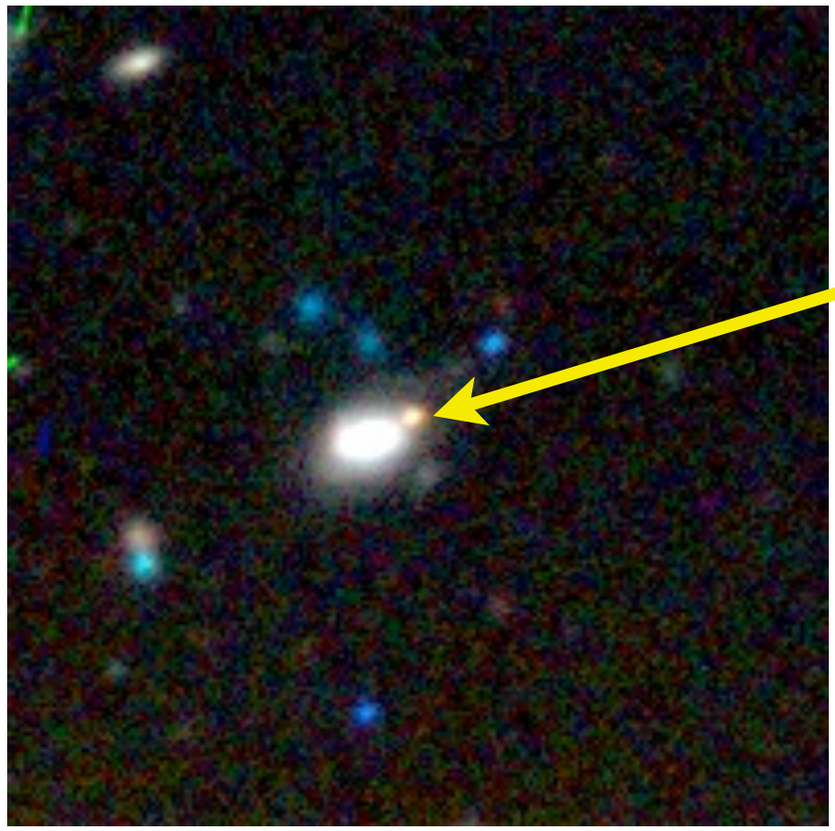

◉ To become a SN candidate:

- multiple observations on different nights and on different filtres ([griz]: 475-925 nm)

Candidate SN200445

RA	Dec	Date	Status	Type
55.30467	-28.99385	20-DEC-12	OK	0

SN Fits

Fit ID	Type	Peak MJD	PEAK MAGB	Delta	Av	z	Chisq

SN Observations

Object	Exposure	Co-Add	CCD	Filter	sec	x	y	RA	Dec	Mag	Chisq	Nite
941283	158629	431475321	31	g	175.0	903	1614	55.30468	-28.99384	22.954	192.3	20121206
947808	158631	431448075	31	i	200.0	906	1617	55.30465	-28.99387	23.318	518.5	20121206
951754	158630	431519212	31	r	150.0	903	1618	55.30475	-28.99392	23.322	306.2	20121206
1605829	159955	431935099	31	g	175.0	907	1684	55.30472	-28.99383	21.856	253.4	20121209
1619119	159956	432019542	31	r	150.0	908	1679	55.30467	-28.99386	22.834	346.1	20121209
2003188	161556	432128112	31	g	175.0	907	1615	55.30470	-28.99384	23.538	287.6	20121215
2010679	161558	432385884	31	i	200.0	907	1611	55.30470	-28.99387	23.619	822.9	20121215
2017247	161557	432385887	31	r	150.0	907	1612	55.30469	-28.99388	22.882	681.3	20121215

"Mag" = apparent magnitude ($m \propto -2.5 \log[\text{flux}]$; human eye limit ≈ 6)

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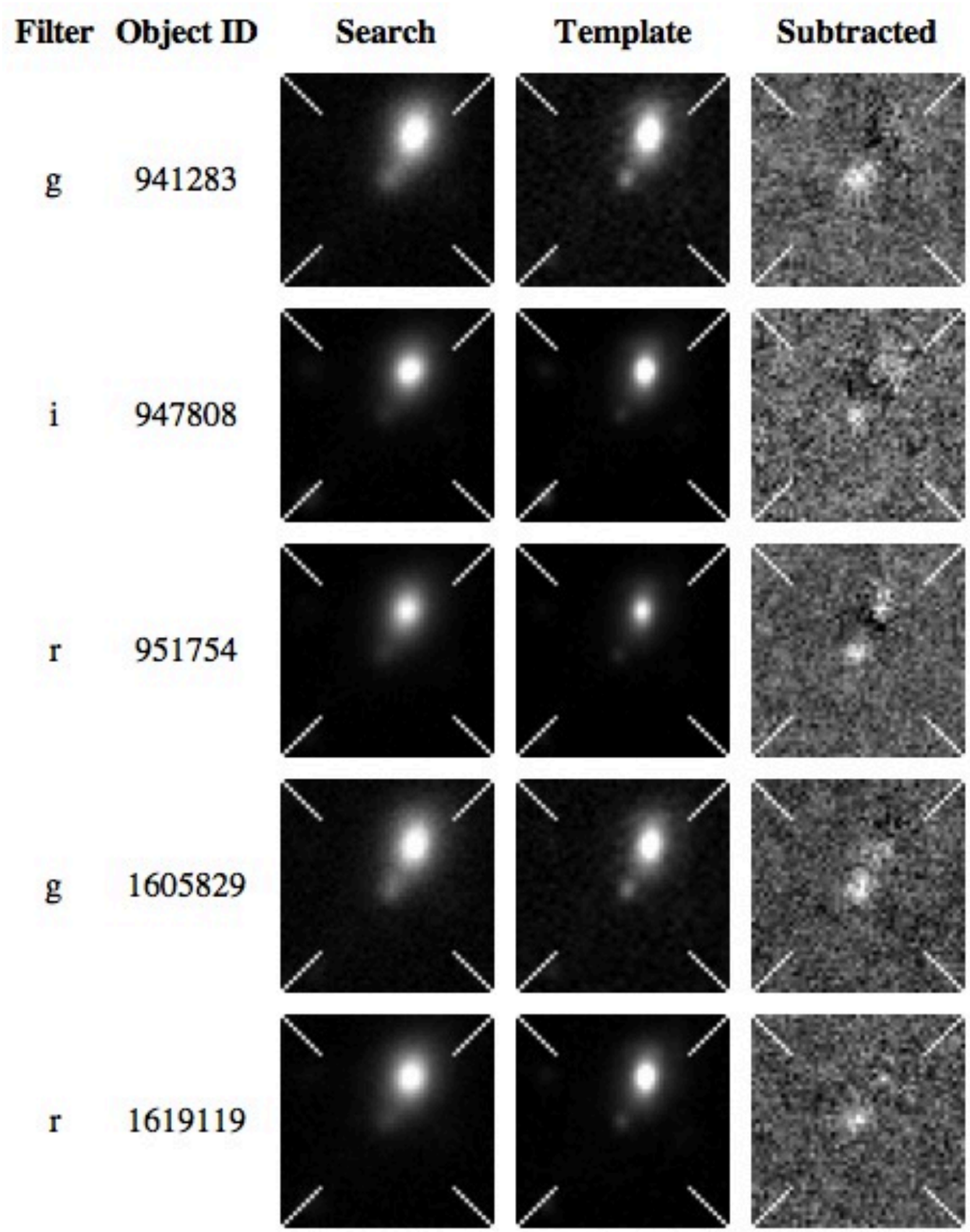

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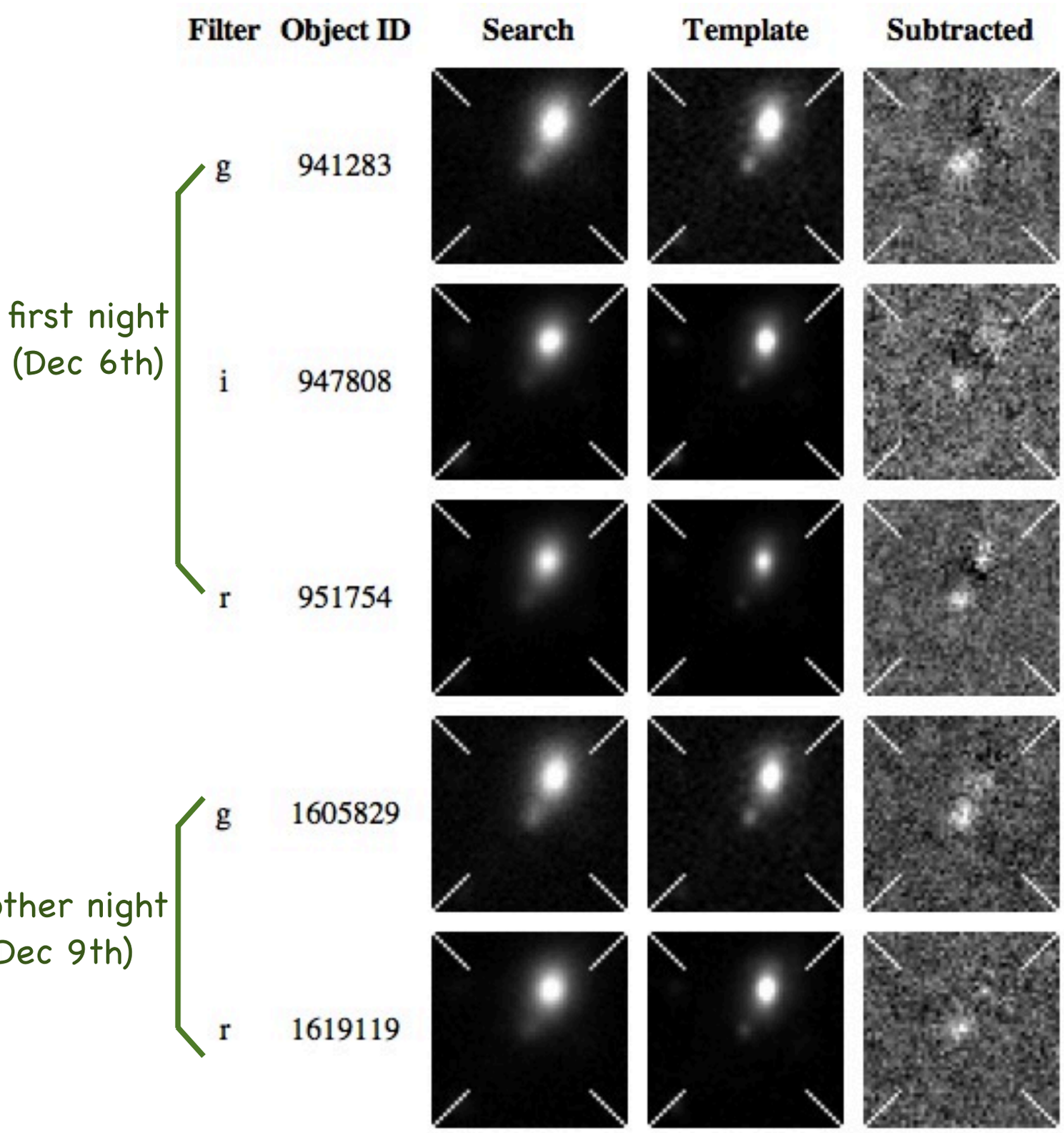

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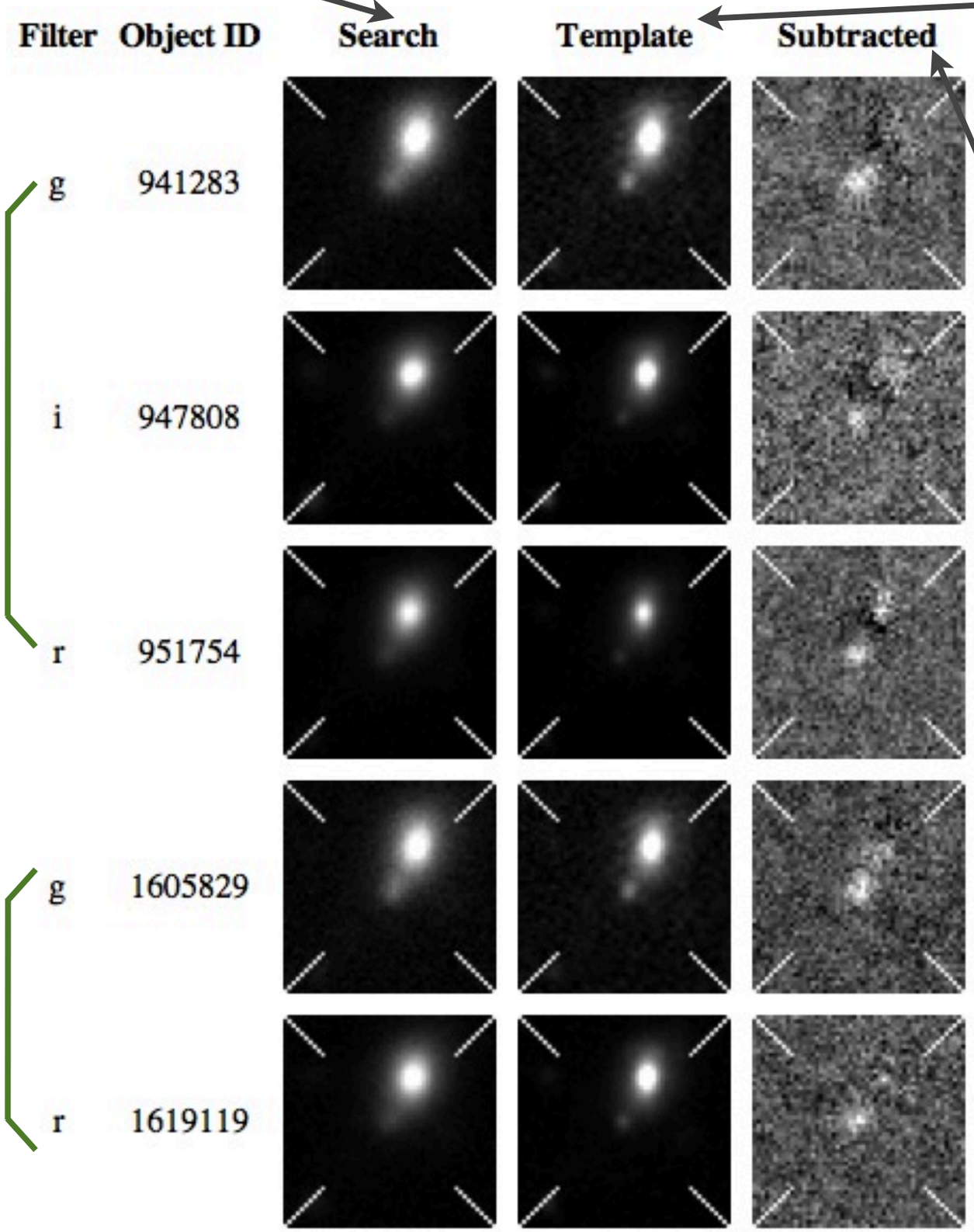
one image



first night (Dec 6th)

another night (Dec 9th)

Composite images taken in different times at the same location (eliminate temporal artifacts)

Subtract template image from search image

- To become a SN candidate:
  - multiple observations on different nights and on different filtres

one image

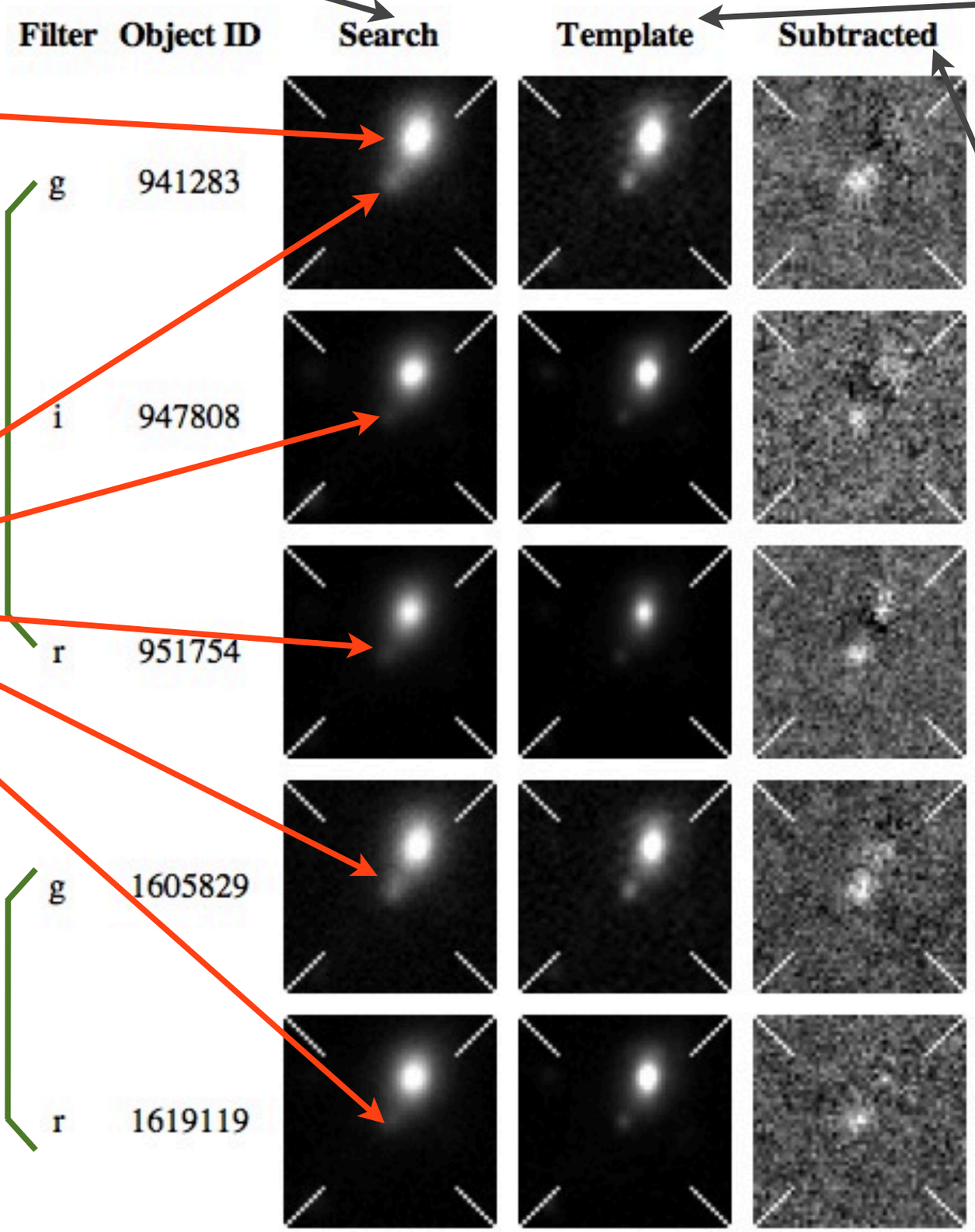
Composite images taken in different times at the same location (eliminate temporal artifacts)

host galaxy

first night (Dec 6th)

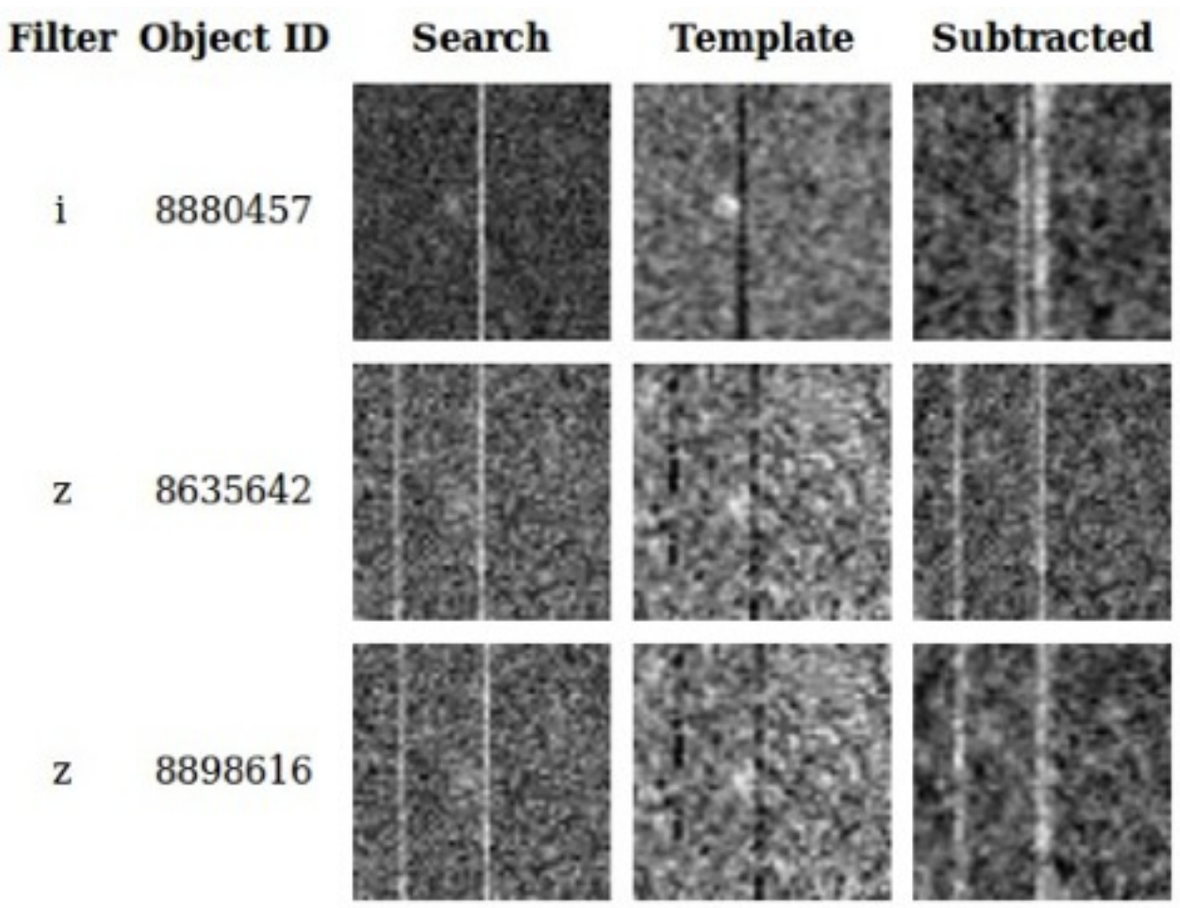
something at edge of host galaxy

another night (Dec 9th)



Subtract template image from search image

- Prevent bad artifacts from entering the candidate list



Example of bad CCD column

- incorporate a comprehensive bad CCD pixel mask and other artifacts into pipeline

- Refine photometric classification scheme
- Working in coordination with other big telescopes with spectroscopic capabilities

❖ So far, many photometric SN candidates, and ...

Three SNIa confirmed spectroscopically with the Anglo-Australian Telescope!!

http://www.astronomerstelegram.org/?read=4668

First SN Discoveries from the Dark Energy Survey

on 22 Dec 2012; 14:34 UT
Distributed as an Instant Email Notice Supernovae
Credential Certification: Masao Sako (masao@sas.upenn.edu)

Subjects: Optical, Supernovae

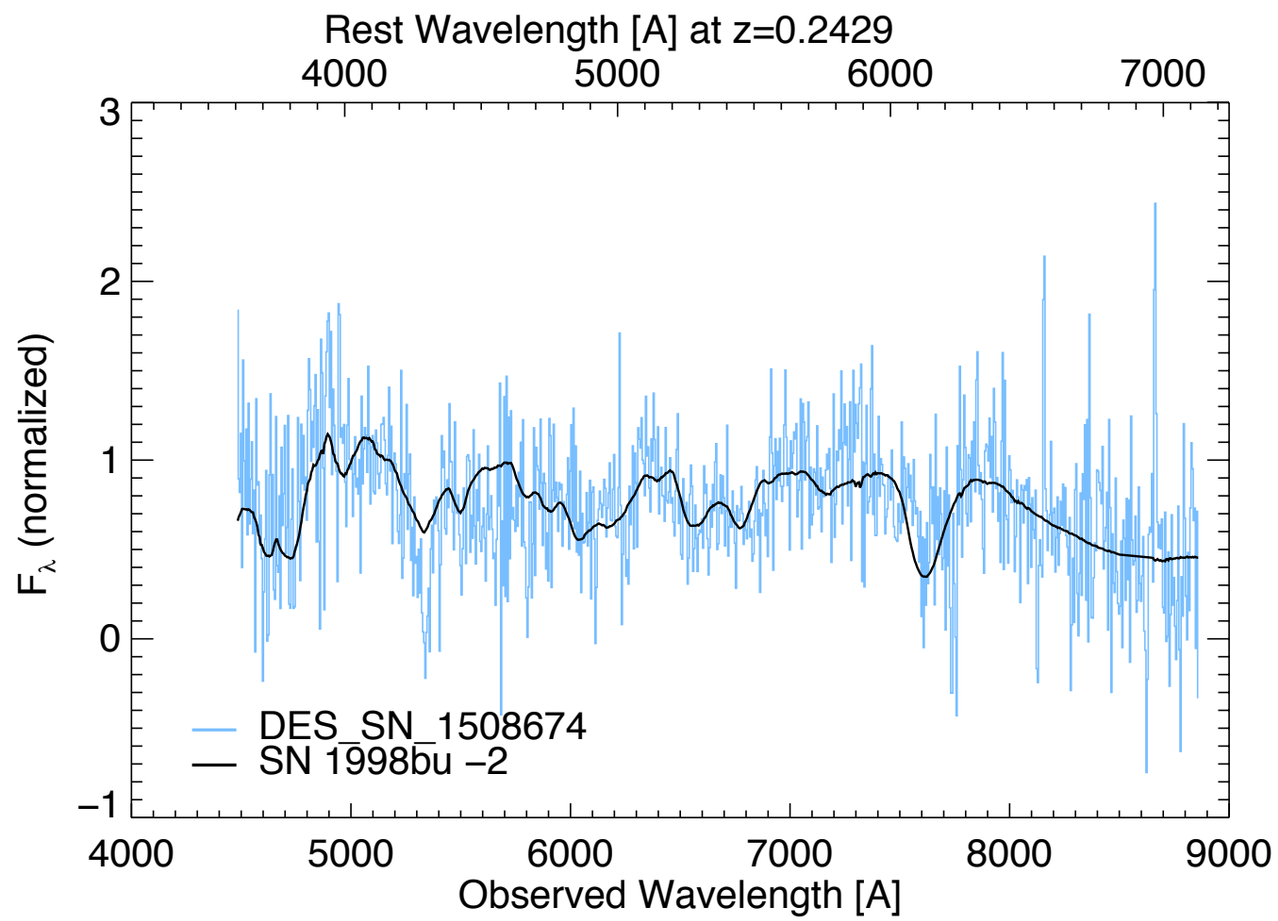
First SN Discoveries from the Dark Energy Survey The Dark Energy Survey (DES) report the discovery of the first set of supernovae (SN) from the project. Images were observed as part of the DES Science Verification phase using the newly-installed 570-Megapixel Dark Energy Camera on the CTIO Blanco 4-m telescope by observers J. Annis, E. Buckley-Geer, and H. Lin. SN observations are planned throughout the observing campaign on a regular cadence of 4-6 days in each of the ten 3-deg2 fields in the DES griz filters. The SN candidates are named according to the season and field in which they were discovered. We adopt the convention -- DES{season}{field}{index} -- where {season} is the year pertaining to the beginning of each observing season, {field} denotes one of the ten SN search fields (E1,E2,S1,S2,X1,X2,X3,C1,C2,C3) in Elais-S1 (E), Stripe 82 (S), XMM-LSS (X) and CDF-S (C), and {index} is one or more lower-case letters starting from a-z, then aa-az, and so on. The DES SN Survey strategy is described in Bernstein et al. (2012, ApJ, 753, 152).

Spectroscopic classifications were performed by the OzDES collaboration from spectra (350-900 nm) obtained at the Anglo-Australian Telescope with AAOmega-2dF observed by C. Lidman, R. Sharp, and S. A. Uddin. Classifications were performed using Superfit (Howell et al 2002, BAAS, 34, 1256) or SNID (Blondin & Tonry, 2007, ApJ, 666, 1024). Redshifts measured from narrow galaxy lines are quoted to 3 significant figures. Those measured from broad SN features are quoted to 2 significant figures. SN phases are based on both the optical spectra and multi-band light curves at the time of the spectroscopic measurements.

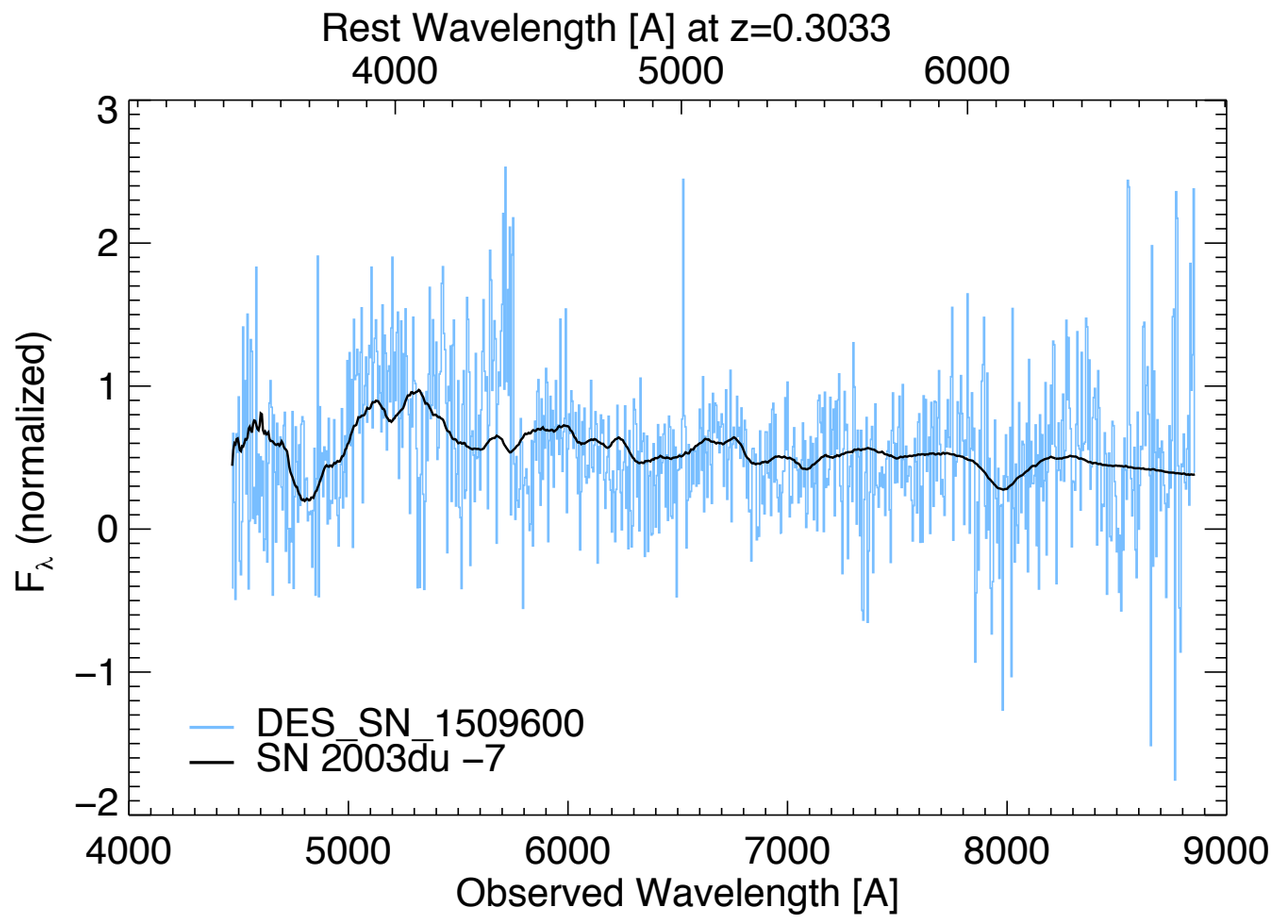
Name	RA(J2000)	Dec(J2000)	Discovery date (UT)	Discovery r mag	Spectrum date (UT)	redshift	type	phase
DES12C1a	03:38:54.5	-27:32:28.2	2012 Dec 07	22.0	2012 Dec 13	0.303	Ia	near max
DES12C1b	03:35:05.8	-26:45:53.9	2012 Dec 07	20.9	2012 Dec 13	0.243	Ia	near max
DES12C2a	03:41:13.1	-28:59:37.9	2012 Dec 04	21.5	2012 Dec 14	0.21	Ia	near max

Spectra matches previously observed SN Ia very well.

DES12C1b



DES12C1a



absolute confirmation

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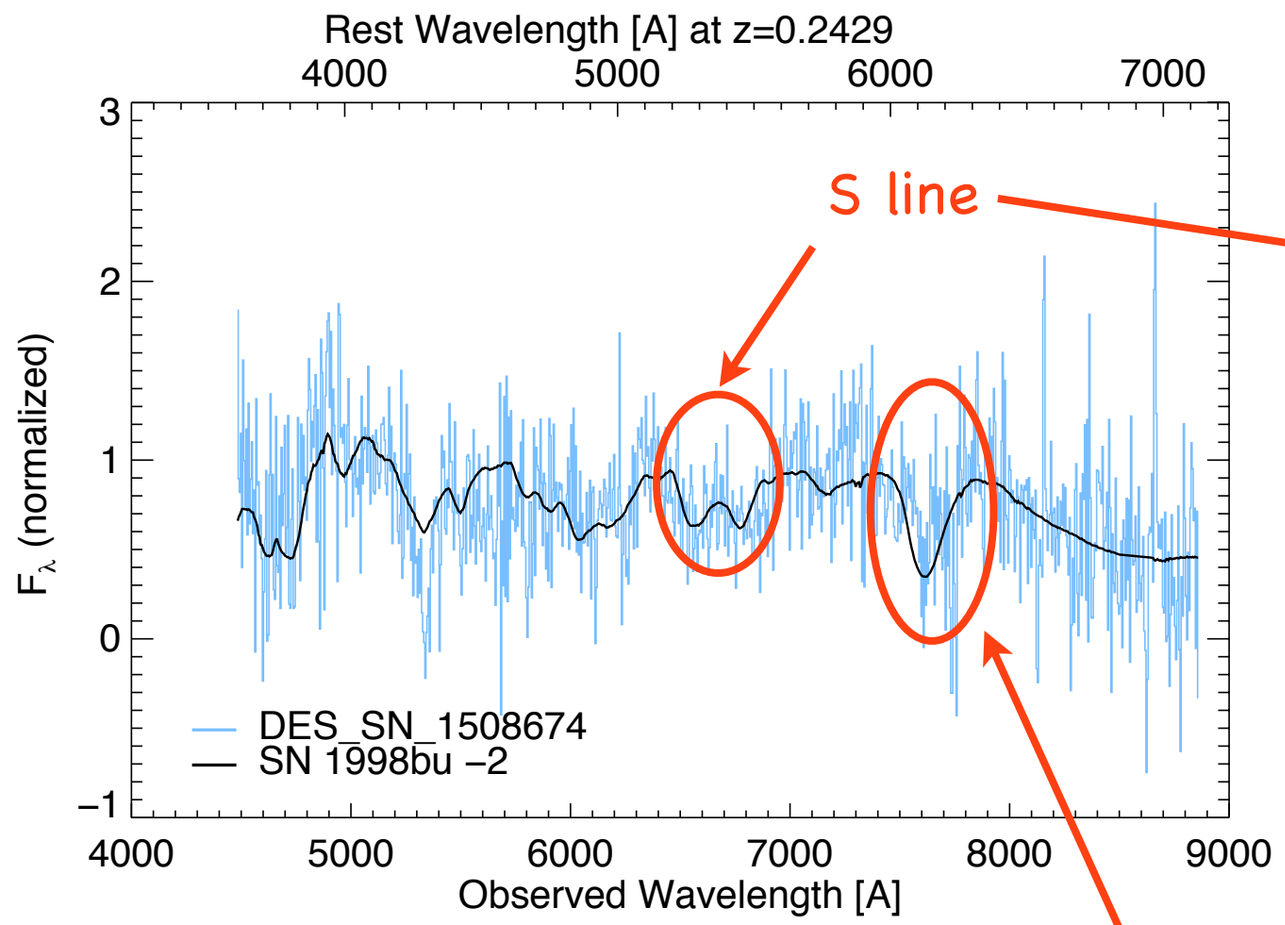
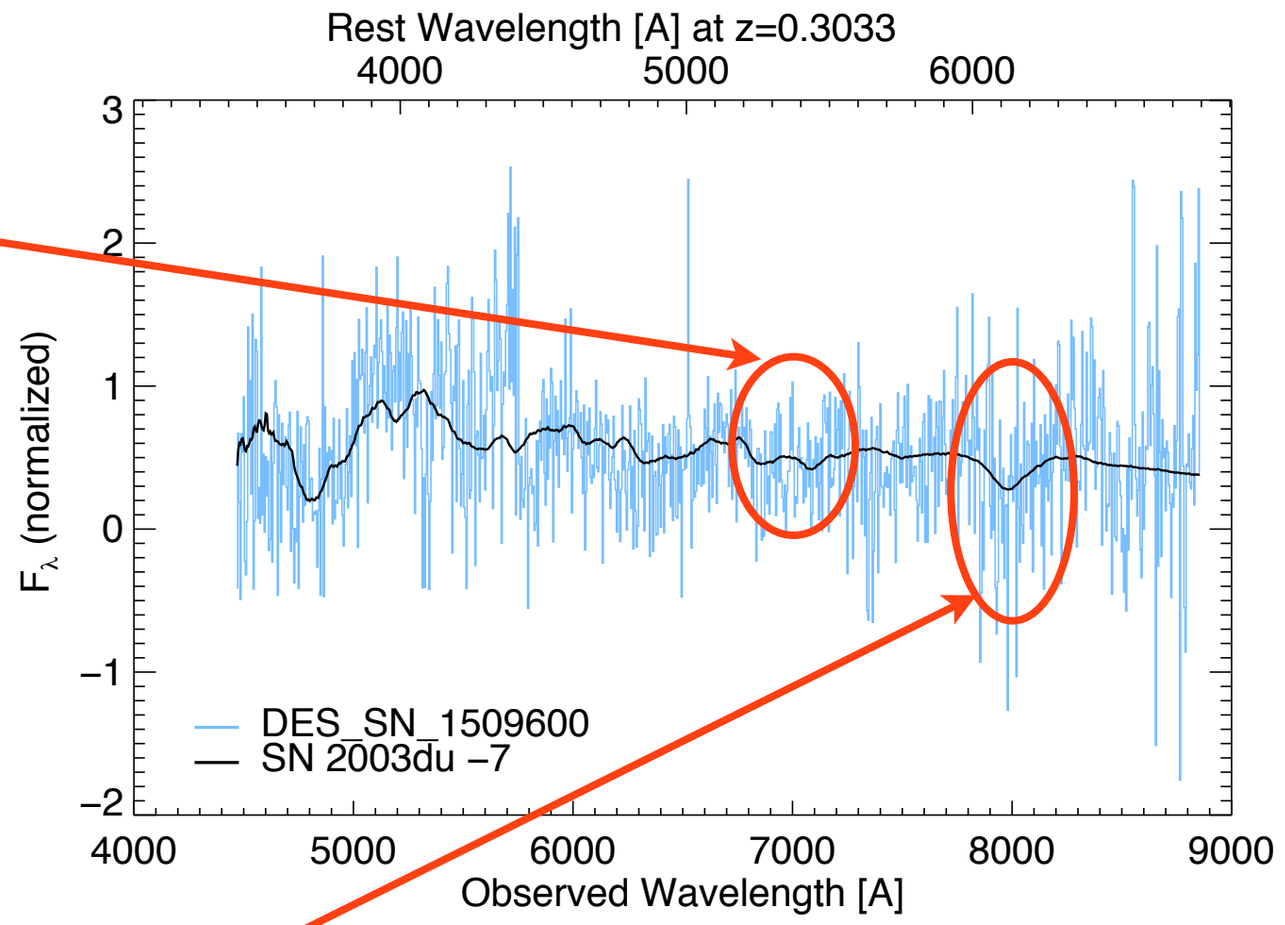


DES12C1a



S line

Si line

absolute confirmation

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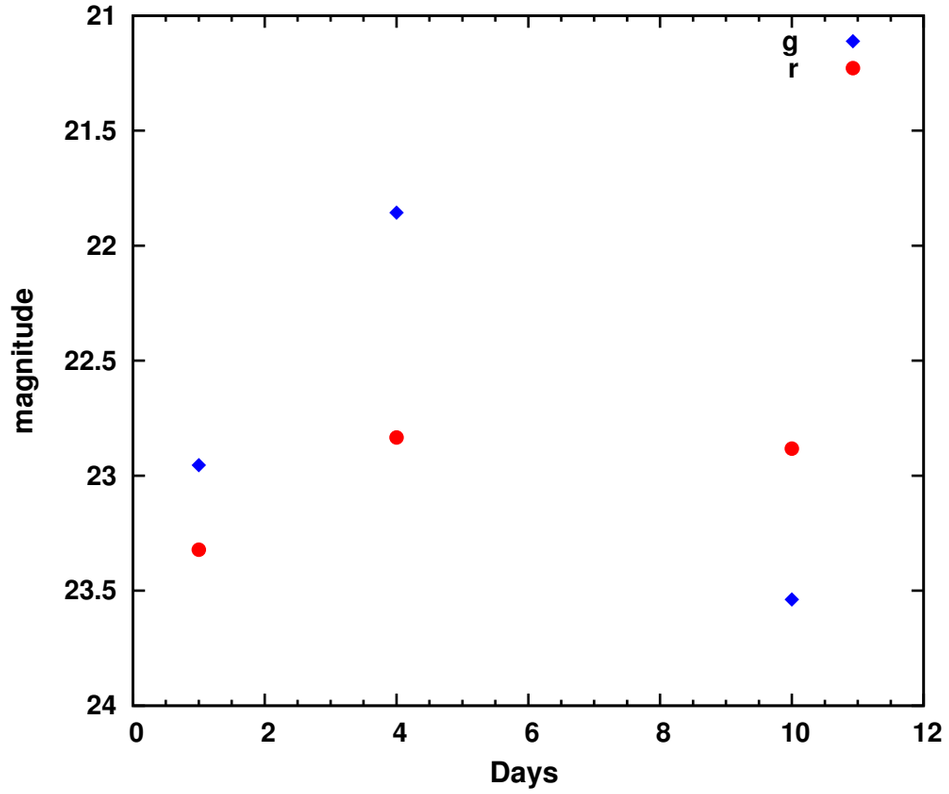
Light curve during Science verification!

DES12C2a



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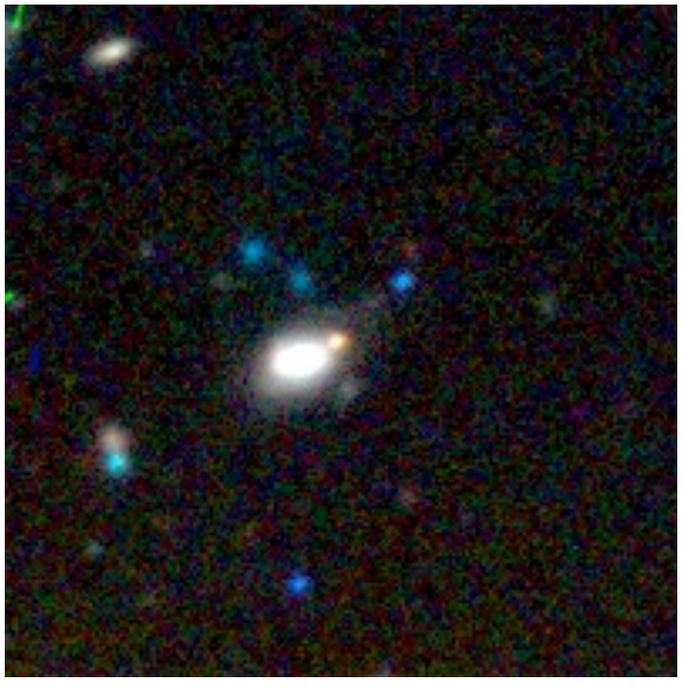
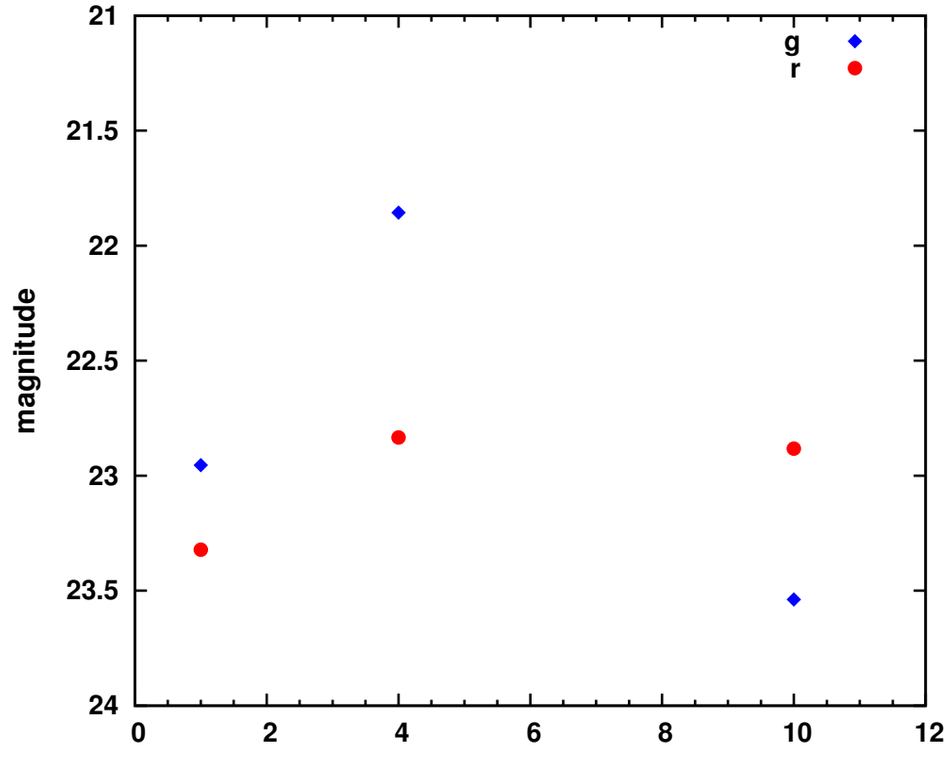
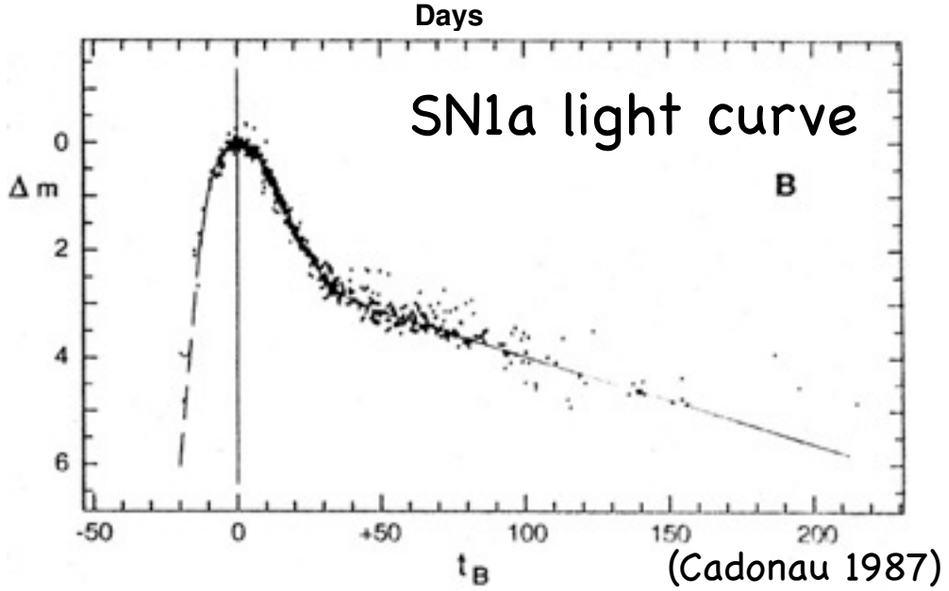


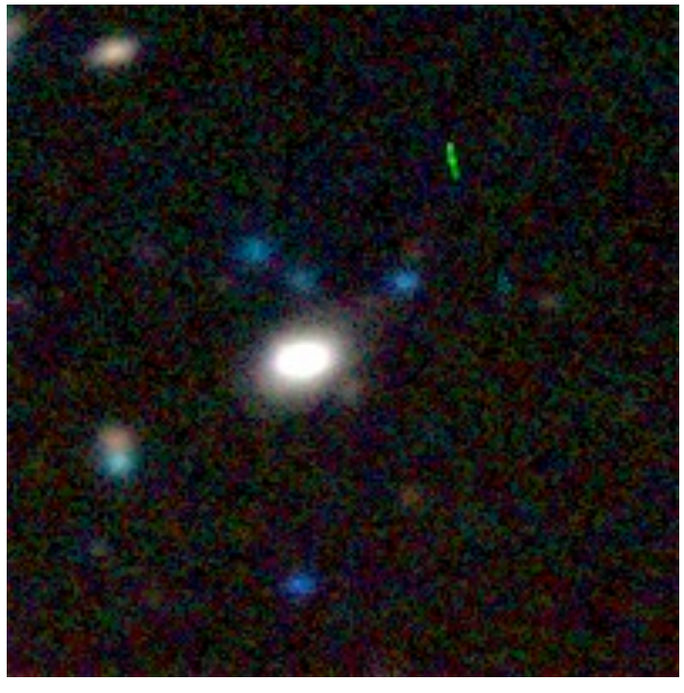
DES12C2a

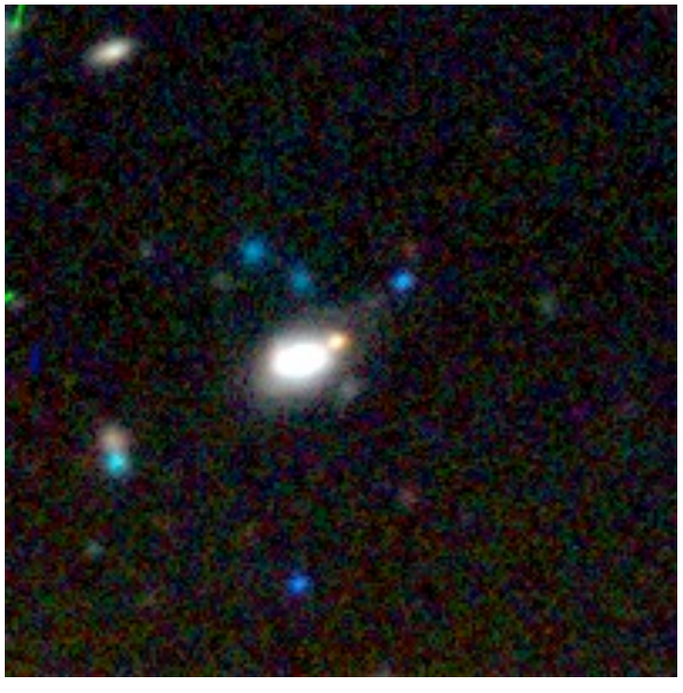




(Cadonau 1987)

Light curve during Science verification!





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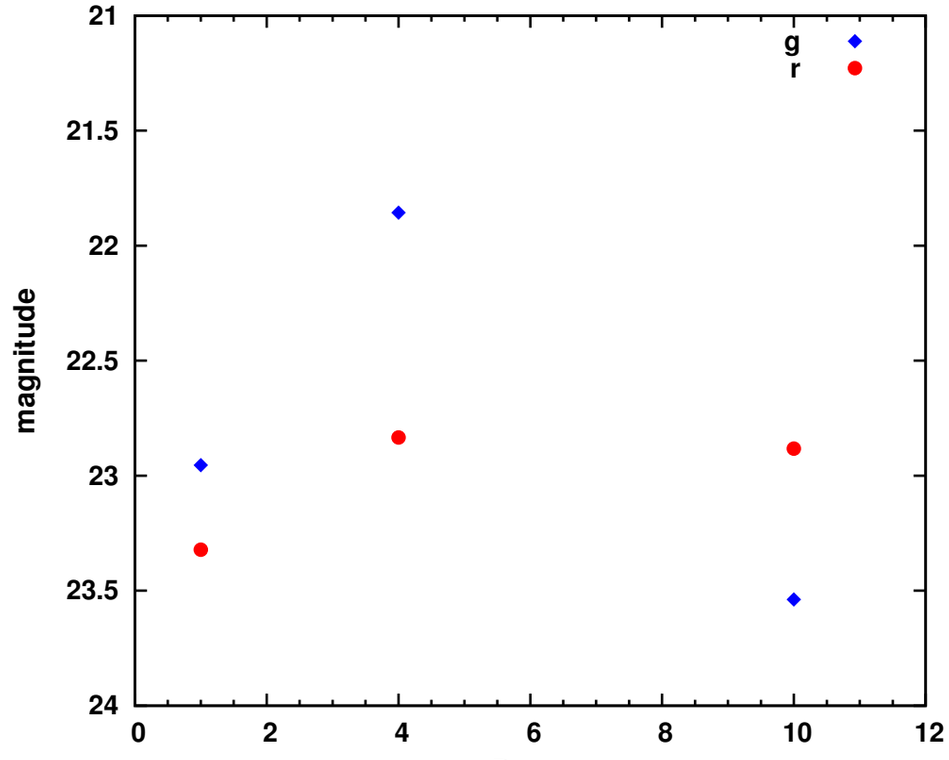

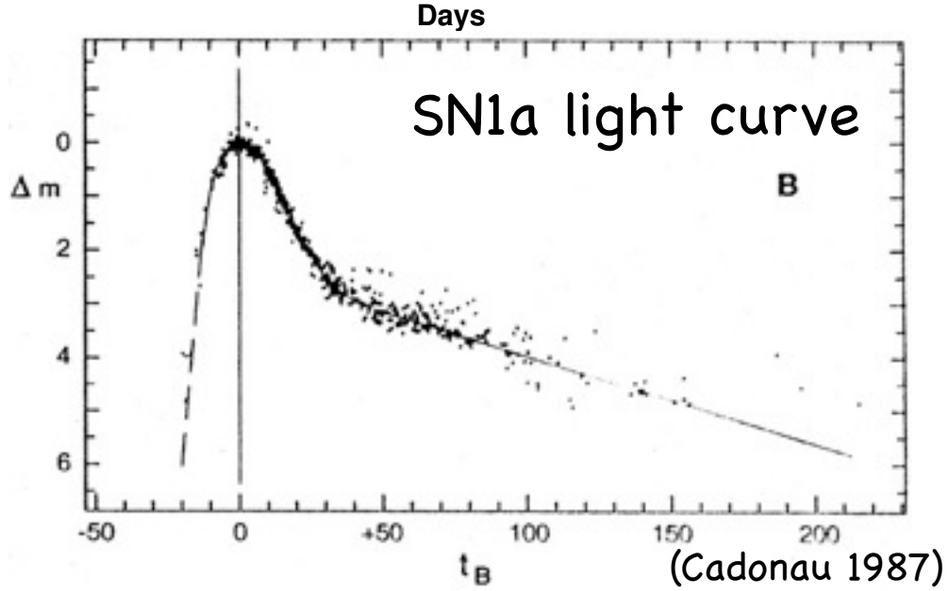

(Cadonau 1987)

Future plans

- Perfect software pipeline
- Continue coordination with other observatories for spectroscopic follow up
- Experiment will go on for ~5 years

➡ Expect more photometric SNIa discoveries and spectroscopic confirmations!